Silvopasture Principles and Practices in Saskatchewan. John Kort (Agriculture and Agri-Food Canada, PFRA Agroforestry Division), Larry White (Saskatchewan Forest Centre), Erl Svendsen Agriculture and Agri-Food Canada, PFRA Agroforestry Division)

# Silvopasture Principles and Potential in Saskatchewan

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## Abstract

Silvopasture is a concept in which woody species are intentionally combined with forage crops and livestock in a production system that optimizes the productivity or the economic benefits of the trees and the animals in a sustainable way. A review is presented of silvopasture research relevant to Saskatchewan conditions. In particular, silvopasture principles, as they apply to the co-management of animals with planted or natural forest stands will be explored. Silvopasture practices that are more or less commonly found in Canada include: the use of livestock to control weeds in new plantations; the planting or management of trees and shrubs as livestock windbreaks or for shade; and livestock grazing in natural deciduous, conifer or mixed forests.

## Introduction

Agroforestry consists of a number of practices in which trees and shrubs are used on the agricultural landscape in an intentional, integrated and intensively-managed system so that the agricultural components beneficially interact with the woody components to result in better overall productivity and sustainability. The term "silvopasture" (alternatively "sylvopasture" or "silvipasture") has been used since the late 1970's to mean the agroforestry practices in which livestock grazing is combined with the use of trees and shrubs (Nair, pers. comm. 2008). When ICRAF (International Centre for Research in Agroforestry) was created in 1978, silvopasture was one of its original areas of study (King 1979). Clason and Sharrow (2000) used the term silvopastoralism to describe the overall concept of combining trees, pastures and animals, and then separated it into integrated forest grazing – the grazing of natural forests – and silvopasture, the more intensive co-management of usually tame forages with commercial forest species.

In the Prairie Provinces, some silvopastoral practices have been traditionally used – mainly the use of trees and shrubs for shelter and shade of livestock and cattle grazing in forests (White 2005). The raising of native livestock, namely elk and bison, involves in different tree/livestock dynamics and presents the need and opportunity to further develop silvopasture practices. The plantation of trees, except in reforestation, has not been widespread in Saskatchewan and thus the combination of livestock with plantations has been little practiced. In general, more research is needed to increase silvopasture knowledge which would justify greater management intensity to increase the value and sustainability of these practices and some ideas in this regard are presented later in this paper.

## Silvopasture in the Aspen Parkland

The suppression or removal of aspen forest is sometimes desirable where aspen forests have developed or are encroaching on grasslands. The area of aspen on the landscape in some parts of the parkland region has expanded since agricultural settlement attributable to the elimination of prairie grassfires that naturally limited aspen growth and re-growth and the gradual change in moisture regime that occurred over the period (Archibold and Wilson 1980). According to Zoltai et al. (1991), climate change could be expected to cause greater expansion of aspen throughout the Prairie Provinces. In situations where pasture managers wish to limit tree and shrub growth, more intensive grazing can be used to simulate pre-settlement grazing pressures. Pasture managers also need to eliminate trees and shrubs from fence lines and access roads for machinery access and from trails to give livestock access to productive pasture.

In silvopasture systems, there is an assumption that trees will be harvested from the same land that livestock is raised on and that there will be benefits from both tree production and animal production (Garrett et al. 2004). Although removal or suppression is sometimes desirable to increase forage availability, the sustainable harvest of aspen forests may present opportunities for the landowner. The commercial use of aspen for oriented strandboard or pulp is well-established but many aspen stands are commercially unattractive because they are over-mature and decadent. Developments in the use of cellulose for bio-energy, either for conversion to ethanol or for direct combustion, may give landowners reasons to harvest the aspen that would allow it to regenerate while simultaneously improving pasture productivity and forage availability.

Trees are a natural part of the Aspen Parkland and in the transition zone with the grainbelt. This suggests that, in this region, the soils and precipitation are sufficient to support tree production including species other than aspen, representing an opportunity for ranchers to adopt silvopasture and other agroforestry practices with lower risk than producers in more arid areas of the prairies.

## Animal Benefits

Trees and shrubs provide shelter and shade for livestock. Windbreaks can be intentionally used and managed to protect animals from wind in summer and winter but these benefits can also come from natural forests. When animals are over-wintered in wooded sites, they are protected from wind and snow and have better health and improved weight gains

(Williams et al. 1997). Ripley and Archibold (1999) reported that the average wind chill in aspen forest from December through February was an average of 417 W $m^{-2}$, or 27%, less than in the open prairie. Moen (1968) estimated that deer required 50% more feed in order to survive in the open compared to aspen forest. Brandle et al. (2000) reported that well-designed shelterbelts could reduce wind speed by more than 50% in a protected zone within 10 windbreak heights. In Quebec, livestock over-wintering enclosures are often created in forests to take advantage of the natural shelter (De Baets et al. 2007). MacArthur (1991) assessed microclimate changes brought about by windbreaks for the protection of sheep and concluded that wind reduction was the critical factor. Quam et al. (1994) recommended tree windbreaks around farmsteads to protect livestock in winter, control snow and facilitate winter-time farm operations.

In summer, livestock can benefit greatly from tree shelter, during hot, sunny periods. Ripley and Archibold (1999) found that the summer air temperature at 1.5 m height under an aspen canopy in Saskatchewan was on average about $1^0$C cooler than in the open prairie during the summer, while Feldhake (2001) reported that summer temperature could be as much as $11^0$C cooler under 80% forest cover in West Virginia. In Ontario, Leuty and Wright (2002) emphasized the importance of trees in pastures to provide summer shade for horses and cattle while Kendall et al (2007) showed that shade significantly reduced body temperatures and respiration rates of dairy cows. At night, radiative heat loss under clear skies is reduced by tree canopies so that night-time temperatures are warmer in silvopasture systems. Sharrow (2000) said that the value of shade for livestock productivity is minor, except in very hot climates, but in noting that livestock preferentially use shade throughout the summer when the weather is hot, did not question its role in increasing animal comfort

## Grazing Effects on Forest Health

Grazing in mostly aspen forests may be managed as a sustainable system that maintains ecosystem function. Productivity and environmental integrity may be simultaneously maintained by managing the grazing time and stocking rates. In particular, continuous summer grazing with high stocking rates causes the forest to be thinned out (Moss pers. comm. 2008). Native shrub density is lower due to cattle browsing on tender shoots of wild rose, chokecherry, saskatoon, hazelnut and wolf willow. Cattle trampling and browsing of young aspen shoots in the early season also reduces shoot regeneration while root trampling and rubbing of older trees leads to a sparser canopy. Broersma et al. (2000) reported that a cattle stocking rate of 0.69 AUM's (Animal Unit Months) per hectare for eight years significantly increased soil bulk density but not to the point of limiting root growth. Lower stocking rates under continuous summer grazing may have little negative effect on the trees while late summer grazing only may be better for the re-growth of shrubs and aspen shoots because, as they develop, they harden and become less palatable to cattle. A method is currently being developed to assess the health of grazed Saskatchewan aspen forests (Kosowan pers. comm. 2008) in which excessive livestock grazing is identified as causing soil compaction in addition to poor hydrological function and nutrient cycling as characterized by the percentage of bare soil. The method also assesses the reduction of understory vegetation and the alteration in herbaceous species composition, including an increase in invasive species such as Kentucky bluegrass and dandelions. According to the assessment method, a healthy forest is one that resembles the condition of a nearby un-grazed reference community.

## Environmental Benefits

Dynamic interactions among the pasture, trees and animals can make silvopasture more productive than if the trees were not a part of the system. Environmental benefits may also be greater than in simpler systems if 1) more habitat is created for large or small mammals, birds, insects, plants and other organisms, 2) soil nutrients and soil water are used more efficiently or 3) herbicide or other chemical inputs are reduced (White 2005).

Large game animals are environmentally and economically important and woodlots or forests that are managed to resemble their natural habitat contribute to their well-being. De Baets et al. (2007) stated that over 230 landowners in Québec raise wild game animals and that there is likely a need for more intensive or planned silvopastoral management of such systems.

## Forest / Pasture Interactions and their Change with Time

Clason and Sharrow (2000) defined three periods in the development of a silvopasture system: tree establishment (through planting or managed regeneration), open-canopy forest and closed-canopy forest.

During the tree establishment period, the trees are too small to affect forage yields or animal productivity; however, competition from grasses, other forages and weeds can seriously and negatively impact tree growth. The shallow root system of establishing trees are at the same level as most of the competing vegetation (i.e. within 30 cm of the soil surface) resulting in direct competition for moisture and nutrients. Also, until the trees are taller than the surrounding vegetation, light competition (i.e. shading) is also a major factor. This is also the period of time when damage from ungulates and rodents can lead to poor form (loss of leader resulting in multi-stemmed trees), reduced growth potential (removal of branches, trunk damage), and even death (trampling, trunk girdling).

In addition to direct and indirect effects from competition, allelopathic compounds [i.e. chemical compounds that one plant produces that inhibits germination, growth or development of another plant] produced by some forage species and weed species may reduce tree growth and survival, especially during the establishment period. The effect is not universal where some species are significantly affected while others are complete immune or even stimulated when exposed to the same allelopathic compound (Ferguson and Rathinasabapathi 2003). Common forage species such as alfalfa, bird's-foot trefoil, tall fescue, red fescue, Kentucky bluegrass, perennial ryegrass, orchardgrass, and smooth brome have all been shown to contain allelopathic compounds that can affect tree growth on a species by species case (Chick and Kielbaso 1998, Larson et al. 1995).

Vegetation control can be achieved in a number of ways including managed grazing (Harris et al. 1984). Allowing cattle and sheep to graze among young trees, though, takes careful management: small trees are easily trampled; if forage is in short supply, then tender shoots and leaders maybe grazed; and the bark of young trees is typically thin and easily damaged through rubbing. Other options to control competing vegetation include using herbicides, mulch, mowing and cultivation.

During the open-canopy period, silvopasture practices can yield the greatest benefits since aboveground and belowground interactions within the system can result in an improvement of overall production (Clason and Sharrow 2000). According to Sharrow (1997), the total productivity, in terms of total biomass, of a fir and forage silvopasture system in Oregon was 60% greater than the same amount of trees and forages grown separately. Luciuk et al. (2003) reported that a closed aspen canopy had much less carrying capacity than an open pasture but that the time to canopy closure was generally far more than ten years after cutting, permitting a significant period of time for productive pasture.

The system's effectiveness depends on how the trees and forage crops share the limited light, water and nutrient resources. Aboveground, partial shade from the trees may benefit the forage crop but deep shade reduces forage growth. Relative humidity is higher and wind speed is less under forest cover and these two conditions are beneficial to water use, the quantity and quality of the forage crop (Huck et al. 2001). Belowground, tree and forage roots compete for nutrients and water, but tree roots can extract water and nutrients from deeper in the soil so that overall water and nutrient use is better in the silvopasture system than in a pasture. The open-canopy period of a silvopasture system depends on the species of trees used, the planting density, the management of grazing and other management practices such as tree pruning or thinning.

According to Krueger (1981), forage production is reduced only when shade from the trees exceeds 35%. In the interior conifer forests of British Columbia, managed cattle grazing is combined with commercial forestry on the same land (Broersma et al. 2000, Small Woodlands Program of BC – Forest Renewal BC 2001). According to Luciuk et al. (2003), forage production under aspen forest canopies decreased as the canopy cover increased where open pasture had an average of 2 AUM $ha^{-1}$ compared to an average of 1 AUM $ha^{-1}$ under full canopy cover and where long-term canopy cover decreased forage production even further.

During the closed-canopy period, only small amounts of forage are available and it is usually of low quality so pasturing is usually not feasible (Harris et al. 1984). Nevertheless, a closed canopy forest can provide valuable shade and shelter in summer and winter. Managed silvopastures can be used in the same way as natural forests and woodlots are currently used for over-wintering or summer shade for livestock. Soil compaction and damage to tree roots is less in winter when soils are frozen, but the producer should always manage the time that livestock spend in closed-canopy forests to reduce the damage to the trees.

## Livestock Management Changes with Time

On-going management is important since a silvopasture system is dynamic and the management practices change according to the growth stage of the trees. Interactions of trees with animals and forage change as the trees age. Livestock choices can differ over time as sheep and goats are lighter and do not cause as much damage to tree roots as cattle do, although sheep and goats readily browse branches. Alternatively, decreasing the number of cattle and the duration of their access to young forest stands is an important means of maintaining tree health. The quality of forage changes over time and some animals like sheep, goats, bison, deer or elk will do better on a mixture of grasses and forbs (Harris et al. 1984). Tree growth is seriously reduced by herbaceous competition when the trees are young so that a vegetation management plan is needed, which may include herbicides, grazing, mowing, haying, cultivating or mulching. As trees get older, the competition by the forage crop becomes less detrimental to the trees but the trees increasingly out-compete the forage crop for light or soil moisture. Pruning or thinning may improve the tree value while allowing more light through the canopy, thus extending the time that forage production is still profitable.

In general, there is an opportunity for the development and increased use of silvopastoral practices. The use of trees and shrubs for windbreaks, especially for winter protection and integrated forest grazing may be improved by the intentional co-management of trees and animals.

## Tree and Shrub Species

Management options depend on the tree and shrub species. In windbreaks, shrubs are ideal for snow management while conifers provide good wind protection throughout the winter. Deciduous hardwoods have the greatest potential wood value when harvested. Clason and Sharrow (2000) suggested that conifers were preferable in Oregon silvopasture because their conical crowns permit better light distribution than deciduous species so that forage production can be maintained for a longer period until full crown closure. Various shrub species that are natural understory species may be intentionally introduced or managed in a silvopasture system to provide browse for large game animals, to provide fruit and for their environmental benefits to biodiversity and protection of soil, water and air. Species selection also depends a great deal on soil type, annual precipitation, available irrigation and other agronomic and management considerations.

Deciduous tree species

Aspen – The major tree species in most grazed forest land in Saskatchewan. Aspen has commercial value for oriented strandboard and pulp but decadent stands may be more useful as a source of biomass for bioenergy. Aspen regenerate from suckers after harvest.

Hybrid poplar – Poplars are very fast-growing and can produce large, straight logs. Poplar wood is relatively soft and light-coloured and can be used for the same markets as aspen and its acceptability has been demonstrated for furniture, window frames, veneer and other higher-value markets (Mater 1998). Vigorous plantations can be harvested within 20 years. They also produce a great amount of biomass that can be used for wood chips or for fuel. In the early years, poplar canopies allow light to penetrate to the forage crops but older plantings can completely shade the area beneath them. Rivest et al (2007) showed that pruning hybrid poplar trees significantly increased the light reaching the ground and was reflected in increased herbaceous growth under them. Hybrid poplars require a lot of moisture and are not suitable on drought-prone land. Herbaceous vegetation will out-compete them when they are young so that vegetation control is important during establishment.

Maple, oak, ash, birch – These species are slower-growing than hybrid poplar but the oak and ash wood may have greater value. Manitoba maple is an important species on floodplains and in other riparian area and has been used for maple syrup production. White birch is native to most of northern Canada and is favoured for use as firewood or other specialty uses such as wood-working.

Conifer tree species

Conifers give good wind protection in winter and, if they are protected from livestock by fencing, they can be used to develop excellent over-wintering sites. Conifers are not very palatable to animals and suffer less browse damage. The open-canopy phase may be longer than the deciduous species that develop broad canopies quickly. Their markets are well-established. They may require pruning in widely-spaced stands to produce high-quality logs. Species which may be considered include jack pine, white spruce, black spruce and tamarack. White spruce are shade tolerant although their growth is reduced by light and soil resource competition from vegetation. Seedlings will survive and grow slowly until they become dominant. Early growth is much better when forage vegetation is managed through mowing or herbicides. Markets for tamarack wood may increase in the future if there is an increased demand for non-treated wood for outdoor household construction (decks, fences and walkways). Scots pine and Siberian larch are introduced conifers that are adapted to Saskatchewan co0nditions and have similar wood properties and market potentials to the native conifers.

Shrubs

Shrubs are generally not of value to the wood industry but need to be considered in the design and management of silvopasture systems. In windbreaks, they can be extremely valuable for snow-trapping as long as they are properly situated. Although some native shrub species are likely to germinate and regenerate in many managed silvopasture systems, new plantings or other sites may benefit from the intentional planting of certain shrub species. Shrubs can provide benefits to the producer and perform many ecosystem services. In winter, shrubs provide browse for large game animals. Shrubs may significantly enhance the biodiversity of the silvopasture by providing habitat such as nesting cover, protection from predators, flowers for pollen, and food in the form of fruit, nuts or twigs for browsing. Dense shrubs reduce soil erosion and sediment flow. The importance of these functions should be considered in a silvopasture system and they should be managed and maintained as necessary.

Willow – Future developments in biomass utilization for bioenergy may make willow species of special interest because of their rapid biomass production potential. Willows occur naturally in low-lying areas and riparian zones and are effective in anchoring riparian soils and protecting water quality. They are important components of the normal biodiversity of many landscapes, providing an early pollen source for insects.

Species such as high-bush cranberry, chokecherry, pincherry and hazelnuts produce fruit that can be used commercially. They are also important for birds and other fauna. Dogwood is especially important in many natural forests for winter browse. It is adapted to browsing because it readily sprouts from the remaining growth. Leuty and Wright (2002) cautioned that the leaves, bark or fruit of some woody species in Ontario have been known to have toxic effects on livestock. In Saskatchewan, chokecherry fruit or leaves can be toxic under certain conditions.

## Silvicultural Treatment

*Spacing.* Wider spacing extends the time of grazing and results in larger trees that may have greater commercial value. It also allows for easier access for maintenance by machines. However, widely spaced trees are more likely to require pruning. If the goal is to develop a normal commercial stand, normal forestry spacings are: 3m X 3m for hybrid poplar, 2.5m X 2.5m for other hardwoods and 2m X 2m for conifers (Doucet et al. 1996).

*Vegetation management.* It is generally difficult to establish trees in perennial forages compared to well-prepared agricultural soils because the forages out-compete the trees and trees may not be established or grow very slowly. The competition may be for light, water and nutrients. If water is plentiful and the herbaceous vegetation is mowed, there will still be some growth reduction in the trees. For tree establishment on agricultural land, competing vegetation is usually killed before the trees are planted. Although reforestation often involves no vegetation management and replanted trees establish nevertheless, their survival and growth is reduced in proportion to the level of competition from other vegetation. In silvopastoral systems, the intentional use of vigorous forage species will reduce tree survival and growth unless it is managed. It is most important to control the vegetation closest to the trees.

Grazing by sheep or goats in new conifer plantings can replace herbicides and reduce herbicide costs, providing income from the land during tree establishment (Boateng

2007). Large animals such as cattle or horses can cause a lot of damage to young seedlings, but sheep and goats are light and careful tending of sheep can reduce the damage that they could otherwise do by biting off the leaders or trampling the seedlings. According to Boateng (2007), 1500 sheep will graze about 5 hectares per day on newly planted forest cut blocks in British Columbia and pasture sizes are generally such that sheep can graze for ten days before being moved to another site. Newly reforested sites are generally grazed for three seasons until the trees are well established. Grazing for tree establishment by sheep or goats has potential for greater use in eastern Canada.

Options:

- Establish the trees first and seed the forage crop afterwards.
- If the forage crop already exists in the field, use cultivation or registered herbicides to control the forage before the trees are planted. Vegetation control may be limited to a small area around the tree, such as a one metre circle (Sharrow and Fletcher 2003). However, allelopathic effects from some forage species should be considered (Chick and Kielbaso 1998, Larson et al. 1995) and site preparation should be completed in the year prior to planting, allowing the allelopathic chemicals to break down.
- Use mulch to prevent vegetation growth near the trees. Black plastic or organic mulches can be placed around the tree seedlings before or after planting to control herbaceous vegetation. Rolls of plastic mulch can be applied by machine on cultivated sites. Plastic squares can protect individual trees on undisturbed soils by using ground staples to hold it in place. Small mammals that can damage seedlings may live in organic mulches
- Use registered herbicides or mechanical vegetation control after the trees are planted. Shielded sprayers, rotary cultivators, mowers or other implements reduce competition for light, nutrients and moisture.

*Protection from animals.* Trees are particularly susceptible to damage by animals when they are young. Chemical or mechanical means are available that protect individual trees from deer cattle, etc. but are generally expensive and some of them may not be effective. In the years of tree establishment, the forage crops may be mechanically harvested or the use of localized fencing such as moveable electric fencing may be feasible to allow animals to have access to the forage crops but not to the trees. If sheep or goats are used for vegetation control during establishment, careful management by an experienced shepherd is essential, especially for the establishment of deciduous species. When simple forest enclosures are created to protect cows and their calves, fences keep the animals together and also protect the trees from the animals. The trees are likely to be healthier and more productive and are better able to perform other environmental functions such as reducing sediment and nutrient flow.

*Thinning*. In general, thinning should not be required in a well-planned silvopastoral system. Trees should be established at the density that is desired at the time of final harvest because high tree density reduces forage yield more quickly. Forest plantations were recommended at 2500 stems ha$^{-1}$ (2m X 2m) for conifers and as little as 1600 stems

$ha^{-1}$ (2.5m X 2.5m) for deciduous trees (Doucet et al. 1996). For fast-growing hybrid poplar plantations, 1100 stems $ha^{-1}$ (3m X 3m) are recommended. Thinning may be required when trying to establish an existing forest stand as a silvopasture. Naturally regenerating aspen or other forests may have high densities of root suckers or seedlings. Even normal forest management sometimes requires thinning treatments. In a silvopasture system, an open canopy is preferred and the degree of thinning should provide this.

*Pruning*. Pruning is a labour-intensive practice that is justified only when high-value straight logs are desired from the silvopasture. Widely-spaced trees have greater persistence of lower branches that grow to a greater size than in denser plantings. If high-value, straight logs are desired, most silvopasture tree species will require some pruning. Species that are normally single stem species will require pruning of lower branches only but some hardwood species will also require selective pruning of upper shoots to ensure the development of a single leader. Pruning allows more light to reach the forage crop and thereby maintains the open-canopy phase for a longer period of time. Generally, the lower branches are pruned and no more than one third of the leaf area should be removed by pruning since more severe pruning will affect the growth of the tree.

## Animal Management

Animals reduce the survival and growth of newly-planted trees by browsing, rubbing or trampling. As with vegetation management, it is especially important to keep animals away from young trees. In cases where tree establishment is threatened more by vegetative competition, animals such as sheep or goats can be used to control the vegetation but they may damage hardwood seedlings through incidental browsing. However, when conifers are being established, or when the treetops are beyond reach, browsing by goats may not be a problem. Small livestock like sheep and goats can effectively control the vegetation but are not heavy enough to cause lasting damage to tree roots, especially when the time that they spend in a specific part of the silvopasture is limited (Williams et al., 1997). Once the trees are 1.5 m tall, sheep can be allowed to graze more freely and, when 2.5 m tall, cattle as well (Sotomayor pers. comm. 2007)

When trees are well-established, animal activities do not usually threaten tree survival but continue to affect tree growth rates. Cattle can cause damage, mainly because they trample the tree roots but also because they rub against the stems. Although forest grazing recommendations estimate the number of AUM’s that are sustainable by the forage production, the timing and duration of the grazing period is important for tree health and performance. The ideal grazing management would include intensive, short-term grazing. Forage reduction under dense canopy cover will naturally reduce the time that livestock choose to spend under the trees when there is pasture nearby, but they will often continue to use the trees for shelter and shade.

Options:

- Fence livestock away from the trees for the first five years
- Use sheep or goats to control weeds by short-term grazing and careful handling
- Minimize the time and maximize the intensity of grazing to minimize root damage and damage to the tree trunks.

## Choice of Forage Species

Lin et al. (1999) found that warm-season (C4) grasses produced poorly under shade while cool-season (C3) grasses tolerated shade of up to 80%. Legumes were variable in their response to shade with white clover and two trefoil (*Desmodium spp.*) species showing good shade tolerance compared to alfalfa or alsike clover. According to White (2005), several forage species (e.g. orchard grass, red fescue, cicer milkvetch and white clover) have been shown to be more shade tolerant than other species. In the later part of the open-canopy stage, shade tolerance may become relatively more important.

## Silvopasture Planning, Management and Monitoring

As with any enterprise, planning and monitoring are important. Range management and forest management planning procedures are well-developed and need to be combined in silvopasture systems. The silvopasture management plan must take account of the long-term productivity decrease of the forage crops as the tree canopy develops and the susceptibility of the trees to damage by animals. The silvopasture management plan should include short-term and long-term tree, animal and forage productivity goals. The plan should detail the procedures that will be used to achieve these goals. The land resources available need to be considered, including the soils and their productivity for both trees and forages. If appropriate, management plans should be created for different geographical areas within the overall system. The plans should include the materials and timing of operations such as establishment of forages and trees, fencing and other infrastructure and the number of livestock and the duration of grazing in different land parcels and at different stages of the silvopasture's development, taking into account the forage availability and the tree requirements. Based on the overall management plan, annual operating plans should be developed each year. Because of the dynamic nature of the system, the annual operating plans will change over time.

An essential part of planning is marketing. Marketing tree products needs to be considered before any tree is planted. Producers need to have a clear idea of the product(s) that can be produced, the length of time required to produce the product, and their present-day value in order to have a realistic idea of what and how to plant, the management requirements, costs and potential income. This doesn't mean that producers need to have a contract in place at planting or not be prepared to change their plans to take advantage of new and more profitable opportunities. Rather, knowing what the end-product is, production costs and product value is an essential part of a sound business plan.

Monitoring should be included in the management plan so that the producer knows if productivity goals are being met and to alert the producer to unforeseen problems so that the plan can be adjusted as necessary. This should consist of on-the-ground assessment of forage condition, tree growth and health as well as monitoring of animal performance. Such monitoring procedures are well-established for both range and forest management.

## Silvopasture Research Topics for Saskatchewan

- *Windbreak effectiveness and cattle behaviour*. Windbreak design for winter protection should include snowtrap and dense windbreak components. The key to an effective windbreak will be the degree to which livestock use and benefit from its protection.
- *Timing and duration of grazing.* Such management can done for possible different results – suppression, maintenance of forest health or encouraging forest regeneration. Methods by which this is done – fencing or other means, may also be compared.
- *Animal benefit and use of shade.* The importance of shade for animal comfort and productivity including cattle, bison, and elk needs further research and can guide recommendations for silvopasture design.
- *Tree harvesting equipment or other management techniques*. Machinery and equipment is essential to the ability of a landowner to mange the land in a economic and sustainable fashion. Silvopasture management to mimic natural disturbances including grazing, harvesting and burning treatments.
- *Forage productivity and quality under shade*. Forage species vary in their shade tolerance and the distribution and quality of native species is an important indicator of forest health.
- *Forest health*. Research related to succession, recovery and habitat quality of grazed or overgrazed forest land. The effect of animals and herbaceous plants on the condition and physiology of trees.
- *Microclimate.* Research is needed to relate livestock and pasture conditions to shade and protection from the trees
- *Nutrient and water cycling*. Silvopasture management for forest health and system productivity depends on understanding and managing resource distribution.

## Conclusion: Silvopasture for Saskatchewan

Windbreaks are important, mainly throughout the winter and are used by livestock producers throughout Saskatchewan for managing snow distribution and protecting cattle. Natural forests or windbreaks can serve these functions, while planted shelterbelts can provide the protection in strategic areas such as feedlots or over-wintering pastures. Shrubs are most effective for snow distribution management while tall conifer windbreaks can provide large sheltered areas that reduce wind chill and improve livestock health, survival and productivity during the winter.

Silvopasture practices can be applied to forest grazing in Saskatchewan. During the establishment of conifers, sheep grazing can be used for weed control. During the open canopy phase, forest health and pasture productivity can be maintained by reducing grazing duration and by limiting grazing to late summer. Early spring grazing can be used to suppress woody regrowth along fencelines or other areas. The natural regrowth of aspen and many native shrubs after harvest presents an opportunity to utilize silvopasture woody biomass for bioenergy as technologies and markets develop to reduce greenhouse gas emissions.

Afforestation plantings are recent in Saskatchewan. Because of the high establishment costs for such plantations, careful silvopastoral management of the land may provide short-term income from the land while the trees are establishing until the point of crown closure. Hybrid poplar afforestation may require more care in grazing management because roots are shallow and susceptible to trampling while they are also susceptible to bark damage from rubbing. In comparison, conifer plantations may be less susceptible to livestock damage as they are not used for browse and conifer species have been successfully used in silvopasture systems throughout North America.

Resources for silvopasture knowledge are becoming increasingly available through on-line and printed sources and there is a need and opportunity to develop and consolidate such resources for Saskatchewan.

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